



# MODELING MULTIDIMENSIONAL MATHEMATICAL ASSESSMENT USING 6-C MATRIX: A MIXED DESIGN

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## ABSTRACT

Dealing holistically with learning centralizes metacognitive and non-cognitive principles that must be integrated in classroom assessment. These dimensions are often overlooked in the instrumentation of assessment tools. In this premise, the researcher designed a new assessment model that looks into manifestations of reflective, affective and metacognitive domains. 6C Matrix is a six-stage tool namely Collect, Create, Concert, Conclude, Connect, and Convey aimed to assess students prior knowledge, concept explored, concept developed, feelings expressed and real-life application. Using mixed design, this study attempts to evaluate and validate the effectiveness of self-structured 6C model in assessing mathematical learning vis-à-vis stimulation of non-cognitive and metacognitive skills. Experiment using pretest-posttest approach comprised two intact groups of Grade 7 students from Libhu National High School SY 2017-2018. Through t-test analysis, experimental group showed higher manifestations in terms of reflective practices, affective behaviors and metacognitive strategies than control group which significantly improve mathematics performance. Positive written feedbacks via thematic analysis substantiated the positive findings in the quantitative results. Based on the findings, this study concluded that 6C Model is an effective assessment tool in mathematics for students' holistic development. Hence, 6C model is recommended for classroom-based utilization for mathematics teachers to make a difference in K12 curriculum.

**KEYWORDS:** 6C-stages, assessment tool, reflective-affective-metacognitive manifestations.

## INTRODUCTION:

Students are expected to become lifelong learners. Therefore they need certain skills to remain active and equipped in the learning process (Masui & De Corte, 1999). Holistic approach to learning situation involves not only cognitive but also metacognitive, affective, reflective, developmental and social principles which influence students' successes (Paris & Ayers, 1994/1999). These principles therefore must be integrated in classroom assessment. According to Glaser (1990), effective assessment practices are considered essential to support mathematics instruction that produces an improved student performance.

However, most assessment instruments designed to assess the needs of students in developmental subjects of K-12 have focused only on academic content along with academic skills. Reviews of intervention studies have revealed that focusing solely such domains does not entirely help teachers attain holistic learning goals (Hattie, Biggs, & Purdie, 1996; Simpson, Hyned, Nist, & Burrell, 1997). There are still other critical dimensions to compliment effective learning that

need to be met in assessment. This includes but not limited to reflective practices, prior knowledge elicitation, affective expressions, real-life application and metacognition, which are often overlooked in the instrumentation of assessment (Tan, et. al., 2013), particularly in our Maasin City Division (MCD), Philippines. Designing a unified assessment model could be helpful to help teachers easily facilitate assessment of not just content but other domains aforementioned at the same time maximize the use of instructional time. Thus, 6C Matrix is herewith defined.

*6C Matrix (literally Six C's)* is a teacher-designed assessment tool characterized by reflective, affective and metacognitive elements that supplement measurement level of both content and skills of learners in mathematics learning. This will give teachers an "all-in-one" instrument for competency assessment cognitively and non-cognitively. 6Cs stands for "Collected, Created, Connected, Concluded, Connected and Conveyed". These areas are defined by the following features:

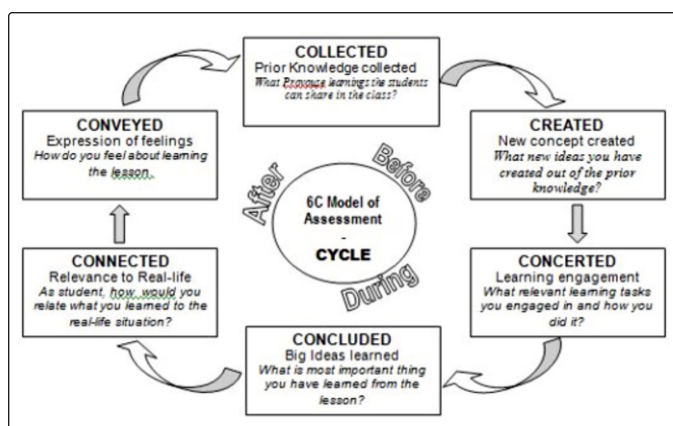
Assessment Stages	Nature of C.	Key Questions	Description	Supporting Authors
Collected	Prior Knowledge Elicitation from the students previously learned concept, topics, skills, ideas	What relevant prior knowledge you have expressed and shared about the lesson?	Students expresses previously learned content that are deemed meaningful to meet new knowledge	Alexander et al., (1994); Glaser, & Farr (1988); Schneider & Pressley (1989)
Created	Creating something new out of the prior knowledge through exploration/ investigation	What are the concepts you were able to uncover and you have done to investigate them?	Students note the activities they conducted during exploration of concept.	Ponte and Matos (1992); Ponte, Brocardo and Oliveira (2003)
Concerted	Cooperative learning tasks engaged in & Metacognitive skills developed	What are the relevant learning experiences that you engaged in to acquire knowledge & skills?	Students express their participation and engagement in diff. activities to acquire knowledge & skills.	Gravemeijer, (1994); Resnick, (1992); Hooper & Temiyakarn (1993).
Concluded	Defining the Concept derived, or Conceptual understanding	What important big idea has been learned?	Students write brief statement as a conclusion of the lesson	Garrison and Anderson, (2003); Igoe, (1993);
Connected	Reflection of the relevance of topic to real life situation	How can you relate the concept to your real life situation?	Students express how they can relate the concept learned to their real-life situations.	Moellwald (1997); Baki et. al. (2009); (Parnell, 2001)
Conveyed	Affective expression of oneself about the learning experience	How do you feel about the topic & the activities developed?	Students express their & satisfaction about the topic & the activities.	(McLeod, 1992). Goldin, (2000); Lazarus (1991)

Previous Literatures revealed that it is difficult to overestimate how much individuals' prior knowledge contributes to learning (Alexander et al., 1994; Bjorklund, 1985; Chi & Ceci, 1987; Chi et.al., 1988). Metacognition plays a central role in the learning process, which ultimately affects the student's mathematical performance (Grizzle-Martin, 2014). Explicitly monitoring and controlling student learning processes help them become more self-directed in their performance (Desoete, 2009). Key findings in the literature also revealed that students perceive difficulties in mathematics and problem solving tasks because they are neglecting a wide range of metacognitive and non-cognitive processes (Grizzle-Martin, 2014; Tok, 2013; Wolf, Brush, & Saye, 2003). According to Artzt,

Armour-Thomas, & Curcio (2008), it is important that students interaction is strengthened in ways that both support and challenge one another's strategic thinking. Subsequently, learning tasks should be structured in ways that allow students to explore, explain, extend, and evaluate their progress. Constructivist teaching recognizes and build on knowledge emphasizing exploration, investigations, reflection, multiple solutions, real life application and explanation of learning processes (Resnick, 1992), which are essential goal-oriented learning behaviors (Oonk & De Goeij, 2006). Affective variables can be seen as indicative of learning outcomes or as predictive of future success. McLeod (1992) identified three concepts used in the research on affect in mathematics education:

beliefs, attitudes and emotions (Goldin, 2000; Lazarus, 1991; Mandler, 1989).

Below shows the framework of the cycle of 6C assessment activities which indicate the phases and facilitating questions to guide teachers how the flow runs in the development of the teaching-learning process. This framework delivers the C-tasks that allow active learners to be thinkers and enable them to be reflectively, affectively and metacognitively aware of themselves to supplement cognitive skills and make them holistically equipped.



### OBJECTIVES:

This study generally aims to evaluate the effectiveness of 6C Assessment Matrix to build reflective, affective, and metacognitive manifestations in learning in relation to mathematics performance. Specifically, this study sought to answer the following questions:

1. What is the level of reflective, affective and metacognitive manifestations of students using 6C model assessment tool in mathematics?
2. What is the math performance of students using the 6C model of assessment?
3. Is there a significant difference in the level of manifestations and performance between students who used and did not use 6C assessment tool?
4. Is there a significant relationship between the usability of 6C model and the mathematics performance of students in the experimental group?

### METHODOLOGY:

This study utilized mixed design. For quantitative aspect, pretest-posttest non-equivalent control group design was used. For qualitative, interview was made to assess the feedbacks of students about the 6C Matrix. Responses underwent data-coding and narrative analysis towards formulation of themes. The study was done in a period of 16 days to two intact classes with 25 students in Section A and 23 students in section B, all of which coming from Libhu National High School, 3rd District of Maasin City Division, Philippines AY 2017-2018. Inductive inquiry-based teaching method facilitated the learning process with provided collaborative learning tasks making use of 6C as an assessment tool before, during and after the teaching-learning process. 6C Matrix was employed for experimental group while conventional evaluation such as pencil paper test, speed test, oral recitation and seatworks were used for control group. 6C Matrix is accomplished by letting students comply all the questions in every C's after which they will report their accomplishments with the class for sharing purposes through cooperative round-table discussion (RTD). This accomplishment will then be checked by the teacher to evaluate how much learning and behavioral manifestations have been achieved by the students upon the task. A researcher-made rubric, validated by experts, was utilized to score the accomplished tool. Furthermore, pretest & posttest were self-structured to determine students' reflective, affective and metacognitive manifestations. To ensure variability of groups, students' 2<sup>nd</sup> Quarter grade in Mathematics were used so that both groups are comparable. It was ensured that respondents completed the experiment while internal validity was kept without intervention of absences. Mathematics

achievement using the summative test of the topics covered was used to correlate with the results manifested in the 6C assessment tools given.

### RESULTS AND DISCUSSION:

#### Level of Reflective, Affective, and Metacognitive Manifestations of Respondents:

Table 1 reveals the level of manifestations between groups exposed and not exposed to 6C assessment. A higher mean gain is attained by the experimental group (1.49) in terms of reflective practices which is highly manifested (M=3.52) compared to control group (M=1.73). Similarly, the affective behaviors (M=3.33) and metacognition (M=3.92) are highly manifested in the group who used 6C model. Results imply that 6C model stimulates reflective, affective and metacognitive behaviors of students. Oonk & De Goeij (2006) emphasized that reflection is one of the essential goal-oriented learning behaviors for acquisition of mathematical knowledge and skills.

Table 1: Level of Manifestations of Respondents

Manifestations	Control Group (conventional assessment)		Experimental Group (6C assessment model)	
	Before	After	Before	After
Reflective practices	1.68	1.73	2.03	3.52
	Not Manifested	Not Manifested	Slightly Manifested	Highly Manifested
Affective behaviors	1.79	2.44	2.21	3.33
	Slightly Manifested	Slightly Manifested	Slightly Manifested	Highly Manifested
Meta-cognition	1.70	1.74	2.39	3.92
	Not Manifested	Not Manifested	Slightly Manifested	Highly Manifested

1.0– 1.74 (Not Manifested) 1.75 – 2.49 (Slightly Manifested) 2.50 – 3.34 (Manifested) 3.25– 4.00 (Highly Manifested)

#### Performance in Mathematics of Students exposed and not exposed to 6C Model:

Table 2 below reflects the summative test results of the two groups. It can be observed that students who are exposed to 6C model (M=18.6; Sd=2.75) perform better than those who are not (M=4.25; Sd=3.6). A difference of 4 points between the mean scores indicates that the experimental group excel better in mathematical learning than control group. This implies that 6C model supports the performance in mathematics. If 6C model is integrated in delivery of lesson, more or less, students become reflectively, affectively and metacognitively aware of the learning process making them active learners.

Table 2: Performance in Mathematics

Level of Performance	Mean Score (N=20)	SD	Description
Not exposed to 6C (Control)	14.25	3.60	Approaching Proficiency
Exposed to 6C (Experimental)	18.60	2.75	Proficient

Legend: 1- 4 (Beginning); 5-8 (Developing); 9-12 (Approaching Proficiency); 13-16 (Proficient); 17-20 (Advanced)

#### Test Results on the Significance of Difference of the Performance between Students Exposed and Not Exposed to 6C Model:

Below shows the mean comparison between groups at different variables. The difference in the scores in terms of reflective practice, affective behaviors and metacognition after the groups are exposed to conventional and 6C interventions respectively is found to be all Significant (p-value=0.000) showing that there is a significant difference in the performance between groups who applied and did not apply 6C Matrix. This difference further implies that 6C is more effective than conventional one. Students who engage in frequent self-evaluation tend to attain higher academic outcomes than those who do not (Kitsantas, Reiser, & Doster, 2004; Schunk, 1996; Schunk & Ertmer, 1999; 2000).

Table 3: Significance of Difference of the Performance between Students

Test Compared	Variables compared	Mean Score			t-test for comparison of means			
		Control	Experimental	Mean difference	t	df	p-value	Description
Post test	Reflective Practice	3.00	4.56	1.56	.67	46	0.000	Significant
	Affective behaviors	2.93	4.07	1.14	.48	46	0.000	Significant
	Metacognition	2.88	4.80	1.92	.71	46	0.000	Significant

Note: Levene's Test Results: F-value= 0.325, sig. value=0.565; equal variances assumed. Result is highly significant at  $p < 0.01$

### Test Results on the Significance of Relationship between 6C Domains and Performance:

Below is the correlation results via chi-square analysis between the nominal variables comprised in the 6C Model and the mathematics performance of students. It shows that there is a significant relationship between the reflective, affective and metacognitive manifestations of 6C assessment and the mathematics performance among students. This implies that 6C model utilization significantly affects development of math performance among students. Bernard & Bachu, (2015) and Desoete (2007) supports that mathematical performance is significantly and positively affected by applying metacognitive strategies.

**Table 4: Significance of Relationship between Math Achievement and 6C Manifestations**

Variables Tested		Test Used	Coefficient	P-value	Interpretation
Independent	Dependent				
Reflective Practices	Mathematics Performance	Chi-Square	.610*	0.017	Significant
Affective Domains			.426*	0.003	Significant
Metacognition			.599*	0.000	Significant

\*relationship is significant at  $p < 0.05$

### Thematic Analysis of Responses taken from direct interviews made to respondents of experimental group regarding experiences in 6C Model utilization:

Besides the result of quantitative data analysis, qualitative data are derived from direct interviews with the students of experimental group was made to self-assess the 6C model integration based on their personal observations and experiences after their engagement to C-stages of self-reflection and metacognition. This was made to validate the findings in the quantitative analysis. The common feedbacks drawn from students were presented in themes below with a corresponding description as elaboration based on the actual responses analyzed.

Themes	Description
6C Model enables students to think critically.	Through the activities in the 6C assessment, the learners become more engaged into the thinking processes by reflecting themselves how they will go about the activities and express it in the class.
6C Model enhances class participation	Assessing students strategies in engaging learning task and how learners go about it encourages them to be more involved and be participative in the "Concerted" phase
6C Model encourages students to reflect on themselves.	The "Created" and "Concerted" phases provide students avenue for self-reflection and metacognition since they are provided probing questions that require them to analyze how they have worked with the given learning tasks.
6C model allows students to express emotionally	The students in "Conveyed" phase allow them to express how they feel about the learning process and share it with their groupmates. Affective behaviors are highly manifested when students open themselves what their heart tells that bring them to better communication and uplift their confidence.

### CONCLUSION AND RECOMMENDATION:

6C Matrix is an effective assessment tool in mathematics that caters students' holistic development. It enable students' reflective, affective and metacognitive skills that significantly contribute to the improvement of mathematics performance. 6C assessment allows the teachers to see how much more can be improved by a student more than his cognitive skills. Hence this tool is highly recommended for use in classroom-based assessment in order to help math teachers attain their respective goals in mathematics teaching. It is also suggested that further study could be developed to strengthen the capability of the model to make a difference in the assessment practices under the Philippine Basic Education Curriculum.

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